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Exploring Plant Biotechnology: Harnessing Pteridophytes for Medical and Agricultural Advancements

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Abstract

Pteridophytes are a group of plants that reproduce via spores rather than seeds and include ferns, horsetails, and club mosses. However, recent scientific investigations have revealed that pteridophytes hold a significant place in traditional medicine systems and can provide a range of therapeutic benefits. Indigenous peoples have used these pteridophytes' medicinal capabilities to treat a variety of illnesses for decades. This study aims to bridge this gap by examining the medicinal potential of pteridophytes and identifying ethnomedicinal pteridophytes thriving in the Dehradun region and its surrounding areas. In addition to learning more about pteridophytes, we identified 28 plants that are traditionally used as medicines in the Dehradun region and its surrounding areas. We researched 28 medicinal plants that fall under 15 different families, representing a wide variety of species, all with special healing abilities. The Pteridaceae family, which also includes the two plants Pteris cretica and Aleuritopteris bicolor, and five species of Adiantum, is the most widespread and dominantone. The remaining 21 plants that are studied in the analysed region belong to other families. These plants are categorized into Pteridaceae, Dryopteridaceae, Lygodiaceae, Polypodiaceae, Ophioglossaceae, Thelypteridaceae, Equisetaceae, Arecaceae, Hypodematiaceae, Aspleniaceae, Tectariaceae, Adiantaceae, Oleandraceae, and Lindsaeaceae Every plant has economic worth in terms of nutritional, aesthetic or medicinal value. Pteridophytes are rich in phytochemicals, such as tannins, alkaloids, flavonoids, carbohydrates, and proteins. These plants exhibit a wide variety of healing methods that the native people used on their own survival, most notably antibacterial, antioxidant, and anti-inflammatory capabilities. Additionally, plants are used to treat lots of skin infections, respiratory conditions, including cuts, burns, and wounds. Ferns are consumed as vegetables worldwide due to their high nutritional value and therapeutic properties. In conclusion, our study emphasis the importance of preserving both the ecological integrity of the Dehradun region and the cultural heritage embedded in the traditional uses of these pteridophytes.

Keywords: Pteridophyte, Pteridaceae, phytochemicals, *Adiantum* species, antibacterial, anti-inflammatory, Dehradun region

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INTRODUCTION

Pteridophytes, which include ferns and fern allies, are lower vascular plants, also known as cryptograms. These plants typically thrive in shady, moist habitats with moderate temperatures, making rainforests – both tropical and temperate – their primary ecosystems. However, they also display an extraordinary adaptability, occupying a wide range of habitats, including those at high altitudes and latitudes (Dixit et al., 2013; Singh et al., 2017). Globally, approximately 9% of pteridophyte species are found in India, despite the country's relatively small landmass, representing 2.5% of the world’s total. In Indian flora, ferns and fern allies form the second largest group of plants, with 31 families, 130 genera, and 1,267 species, of which around 70 species are endemic to India (Botanical Survey of India).

Ethnomedicine, on the other hand, refers to traditional medicinal practices that incorporate cultural interpretations of health, diseases, and healing processes. Plants play a central role in ethnomedicine due to their ability to produce secondary metabolites, which are species-specific compounds that vary widely in structure and bioactivity. These secondary metabolites – such as phenolics, terpenoids, alkaloids, proteins, and peptides – are primarily used by plants as defensive mechanisms against pathogens and herbivores (Krippner and Staples, 2003). The rich diversity of pteridophytes, combined with their bioactive compounds, holds great potential for ethnomedical applications, particularly in India.

Pteridophytes, commonly known as ferns and their allies, are a group of lower vascular plants that occupy a unique evolutionary position between non-vascular bryophytes and higher vascular seed plants (spermatophytes). Classified under the cryptogams due to their spore-producing nature, these plants lack seeds and flowers but are fully equipped with vascular tissue for water and nutrient conduction, a trait that allows them to grow larger and inhabit diverse environments. Though ferns and their allies are typically associated with moist, shady environments, such as tropical and temperate rainforests, they exhibit remarkable adaptability, occurring in a wide variety of habitats, from deserts to alpine regions, making them ecologically diverse (Dixit et al., 2013; Singh et al., 2017).

Ecological Distribution and Habitat Preferences

Pteridophytes are widespread globally, with around 12,000 species, the majority of which are found in tropical regions where rainfall, humidity, and consistent temperatures support their lifecycle. Their distribution, however, is not limited to these regions, as ferns have also adapted to temperate and subtropical zones. In these habitats, they often grow in understory forest environments, thriving in the absence of direct sunlight and benefiting from high levels of soil moisture. Certain species of ferns are also known to grow epiphytically, living on other plants without causing them harm [1–3].

Interestingly, ferns can also be found at higher altitudes and latitudes, demonstrating their resilience. For instance, alpine ferns have adapted to cold climates, showing unique survival mechanisms, such as reduced size and slow growth rates. Similarly, some species inhabit xerophytic (dry) environments by developing specialized structures like thickened fronds or scales that reduce water loss. This adaptability to diverse conditions highlights the evolutionary success of ferns and their allies, making them important components of their respective ecosystems.

India harbors a significant portion of the world’s pteridophyte diversity. Although India covers only 2.5% of the world’s total land area, it is home to approximately 9% of the world’s pteridophyte species, a testament to the country’s varied topography and climate. The flora of India includes 31 families, 130 genera, and 1,267 species of ferns and fern allies, with around 70 species being endemic to the region (Botanical Survey of India). This wealth is largely attributed to the country’s varied ecosystems, ranging from the Western Ghats and the Himalayas to the northeastern states and Andaman and Nicobar Islands [4, 5].

Historical Importance and Utilization of Pteridophytes

The historical importance of pteridophytes, particularly in traditional medicine, has been well-documented. Ferns have been utilized by indigenous cultures across the globe for their medicinal properties, owing to the variety of bioactive compounds they produce. These plants are considered valuable for their use in treating ailments ranging from fever and wounds to digestive and respiratory disorders. For example, in India, the medicinal uses of ferns like *Diplazium esculentum* (commonly known as vegetable fern) have been widely reported in various indigenous systems of medicine.

In addition to their medicinal applications, ferns have cultural significance. Many species, such as *Cibotium barometz* (woolly fern), have been used in folklore and rituals due to their unique characteristics. The iconic spiral shape of young fern fronds, known as a fiddlehead, is often considered a symbol of rebirth and new beginnings in various cultures.

Pteridophytes and Ethnomedicine

Ethnomedicine is the study of traditional medical systems that are deeply rooted in specific cultural contexts. These systems often involve the use of plants and other natural resources for healing and maintaining health. In many traditional societies, pteridophytes have played a significant role in ethnomedical practices, thanks to their diverse range of bioactive compounds. Ethnomedicine does not merely refer to the use of plants for medicinal purposes but encompasses a broader understanding of health and healing, one that includes cultural, spiritual, and ecological perspectives.

Plants, including pteridophytes, produce a wide array of secondary metabolites that are not directly involved in growth or reproduction but serve essential functions in defense against herbivores, pathogens, and environmental stress [6]. These secondary metabolites – such as phenolics, terpenoids, alkaloids, and glycosides – are often responsible for the therapeutic properties of plants. For example, certain ferns produce alkaloids with anti-inflammatory properties, while others synthesize compounds that have been found to exhibit antimicrobial or antioxidant activities (Krippner and Staples, 2003).

In India, pteridophytes are well-represented in ethnomedicine. Indigenous communities, particularly in northeastern India, the Western Ghats, and the Himalayan region, have long used ferns for their medicinal properties. Species, such as *Adiantum capillus-veneris* (maidenhair fern) are used to treat respiratory ailments, while *Pteris vittata* (brake fern) is traditionally applied to heal wounds and skin infections [7, 8]. The bioactive compounds extracted from these plants hold promise not only for their continued use in traditional medicine but also for their potential applications in modern pharmaceutical research.

The Chemistry of Secondary Metabolites in Pteridophytes

The secondary metabolites produced by pteridophytes vary widely in structure and function, offering a rich source of potential therapeutic agents. These compounds can be broadly classified into three main categories: phenolics, terpenoids, and alkaloids. Each of these groups of chemicals plays a different role in the plant's survival and offers different types of bioactivities that can be harnessed for medicinal purposes.

- *Phenolics:* These compounds are known for their antioxidant properties, which help in neutralizing harmful free radicals. The antioxidant activity of phenolics has been linked to the prevention of chronic diseases, such as cancer and cardiovascular conditions. In ferns, phenolic compounds are particularly abundant, with many species showing high antioxidant potential.
- *Terpenoids:* This large class of organic compounds play various roles in plant physiology, including serving as defense mechanisms against herbivores and microbial infections. Some terpenoids have been found to exhibit anti-inflammatory and anticancer activities, making them of significant interest to pharmaceutical industries.
- *Alkaloids:* These nitrogen-containing compounds are known for their diverse pharmacological effects, ranging from pain relief to antimicrobial activity. Alkaloids found in certain pteridophyte species have shown promising results in treating conditions, such as malaria, infections, and inflammation.

The medicinal potential of these secondary metabolites has not gone unnoticed by modern science. Research into the pharmacological properties of pteridophytes has revealed that many species produce compounds with potent biological activity, leading to their inclusion in drug discovery programs. For instance, ferns belonging to the genus *Dryopteris* are being studied for their antifungal and anticancer properties, while extracts from *Pteridium aquilinum* (bracken fern) have shown promise as a source of natural antioxidants.

Ethnobotanical Research and Conservation Efforts

With growing interest in ethnomedicine and the pharmacological potential of pteridophytes, there has also been an increasing awareness of the need for conservation efforts. Many species of ferns and fern allies are under threat due to habitat destruction, climate change, and overharvesting for medicinal use. Conservation efforts are critical, particularly in biodiversity hotspots like India, where many endemic species are at risk.

History and Origin

The nonflowering vascular plants are called pteridophytes (from the Greek: pteron, feather, phyton, plants). Therefore, they could be referred to as “vascular cryptogams.”

About 400 genera and 10,500 species, including both living and extinct plants, serve as their representation.

They are the earliest known vascular plants, having developed throughout the Devonian to Permian periods (400 million to 400 million years ago) and emerging as the planet’s predominant flora.

The successful colonizers of land habitat are pteridophytes. They had developed a few distinguishing traits throughout the early geological era, which aided in their successful adaptation to life on land. Pteridophytes emerged during the Silurian period and then underwent diversification in the Lower Devonian (Neelesh, 2016).

Distribution

Pteridophytes can develop in a variety of environments. They mainly exhibit terrestrial characteristics that thrive in humid, cool, and shaded environments. Water is necessary for the transportation of male gamete to the female gamete in all pteridophytes to complete sexual reproduction.

Some members are aquatic (e.g., *Azolla*, *Isoetes*, *Marsilea*, *Salvinia*) or xerophytic (*Selaginella lepidophylla, S. rupestris, Equisetum arvense)* and maximum are epiphytic (*Lycopodium phlegmaria, Selaginella oregana, Ophioglossum vulgatum,* ferns like *Polypodium, Drynaria, Pleopeltis*, etc.).

Pteridophytes include small annual herbaceous plants like *Azolla* as well as big perennial trees like *Alsophila* and *Cyathea*. Pteridophytes are often herbaceous in nature (Neelesh, 2016).

Characteristics of Plant Body

i. The main plant body is a sporophyte, which is divided into roots, stems, and leaves. It is nutritionally independent. Some primitive members, like *Rhynia*, *Cooksonia*, and *Psilotum*, do not actually have roots or leaves.
ii. The diploid (2n) zygote gives rise to the sporophyte. The adventitious roots eventually take the place of the transient primary roots.
iii. The stem typically has dichotomous or monopodial branches.
iv. The leaves might be simple, tiny and sessile (like those of the ferns *Pteris species*), scale-like (like *Equisetum species*), or compound, big and petiolate.

Adaptation of Pteridophytes Plants

Pteridophyte spores are surrounded by two concentric wall layers, the outer of which is thick and acid-resistant and the inner of which is thin and acid degradable. The spores can defend themselves

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against harmful environmental conditions like desiccation or acid treatment. This desiccation-resistant spore was a crucial development that made it possible for plant life to spread across terrestrial surfaces [9, 10]. All exposed areas of land vascular plants have a surface cuticle. The main purpose of the cuticle is to control transpiration. Additionally, it has resistance to microbiological attack, chemical compounds, gas exchange, abrasion, and mechanical harm (Neelesh, 2016).

Terrestrial plants have evolved stomata, which regulate the movement of gas and water based on the needs of the plants, because the cuticle prevents gaseous exchange.

Fern allies have variously included the lycopods (*Lycopodium*, and *Selaginella*), horsetails (Equisetum), whisk ferns (Psilotum and, Ophioglossaceae), water ferns (Marsileaceae), and sometimes even members of Schizaeaceae and Gleicheniaceae (Christenhusz & Chase, 2014) [8].

Pteridophytes, such as ferns are largely used by humans as a source of food, fiber, craft, abrasives, decoration, materials and medicines (Figure 1). The tribal groups use stem, rhizome, spores, fronds, and pinnae for treating various human ailments.

- Vegetables include the young fern leaf tips, *Circinate ptyxis*, and chroziers. In India, young fronds of *Ampelopteris prolifera* are marketed as “dheki shaak.” In the United States and Canada, the croziers of *Matteuccia struthiopters* are offered as spring vegetables in canned or frozen form. *Marsilea* leaves, also known as “shushni,” are consumed as a vegetable.
- Many ferns, including *Pteris*, have starch-rich rhizomes that are used as food.
- Pigs, ducks, and other animals eat the corm (modified stem) of the *Isoetes* plant.
- Many ferns’ dry fronds serve as the cattles livestock. *Marsilea’s* quadrified lamina, which resembles a clover (*Trifolium*), has been utilized as an alternative to clover as animal feed.

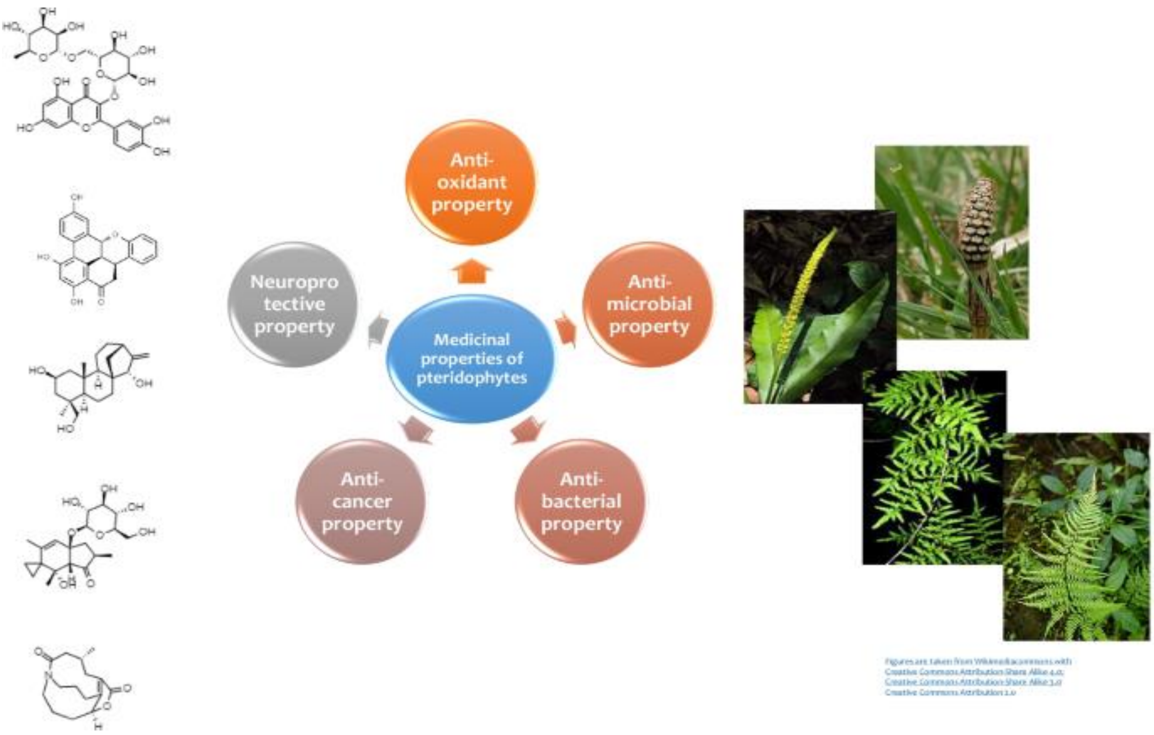

Figure 1. Medicinal properties of pteridophytes (Bandyopadhyay and Dey, 2022) [5].

Purpose

The study aims to offer valuable insight into the medicinal potential of pteridophytes found in Dehradun district and its surrounding areas including Chakrata forests and Mussoorie hills as well as their role in the contribution and use of natural therapeutic agents for improving human welfare.

Problem Statement

The problem statement behind the search revolves around the exploration and documentation of these plants in medicinal practices, as well as their cultural significance in indigenous communities and their role in maintaining cultural habitats generally. Documentation of the ethnomedicinal pteridophytes addresses a complex interaction of conservation, traditional knowledge, modern science, and cultural preservation.

The Objective Includes

- To find out the uses of different plant parts of the pteridophytes in the Dehradun region.
- To find out the different ethno-medicinal properties in the pteridophyts plants studied.
- To signify and highlight the pteridophytes for use in the field of medicine and to improve the knowledge of plants in human welfare.

CONCLUSIONS

Pteridophytes represent a vital group of lower vascular plants that contribute to ecological diversity and hold significant medicinal potential. Their role in ethnomedicine, particularly in regions like India, where they are abundant and deeply integrated into traditional healthcare systems, underscores the importance of further research and conservation efforts. As secondary metabolite producers, ferns and their allies offer a vast array of bioactive compounds that could be harnessed for modern therapeutic applications. Continued exploration of these plants in both ethnobotanical and pharmacological contexts promises to yield valuable insights into their role in health and medicine.

REFERENCES

1. Admin B. Pteridophyta - characteristics, life cycle, classification & examples, BYJUS. 2021. Available at https://byjus.com/biology/pteridophyta/
2. Akulova Z. *Dryopteris juxtaposita* [Image]. Calphotos. 2010. Available at https://calphotos.berkeley.edu/cgi/img_query?seq_num=322248&one=
3. Balles. Maidenhair fern *(Adiantum capillus-veneris)* in Anento (Zaragoza, Spain). Wikipedia. 2020. Available at https://en.wikipedia.org/wiki/Adiantum_capillus-veneris#/media/File:Adiantum_capillus-veneris_2601.jpg
4. Ballings P. *Adiantum lunulatum* [Image]. Flora of Zimbave. 2012. Available at https://www.zimbabweflora.co.zw/speciesdata/image,,display.php?species_id=101010&image_id=1.
5. Bandyopadhyay A, Dey A. Medicinal pteridophytes: Ethnopharmacological, phytochemical, and clinical attributes. Beni-Suef Univ J Basic Appl Sci. 2022;11:113. doi: 10.1186/s43088-022-00283-3.
6. Barcelona JF. Image of *Hypodematiaceae Hypodematium crenatum* [Image]. 2013.
7. Bisht AS, Bhatt AB. A contribution to the medicinal plants of Sahastradhara, district Dehradun, Uttarakhand (with ethenobotanical notes). J Drug Deliv Ther. 2012;2(5).
8. Christenhusz MJ, Chase MW. Trends and concepts in fern classification. Ann Bot. 2014;113(4):571–594. doi: 10.1093/aob/mct299.
9. Deoli J, Yadav VK, Negi M. Ethno-medicinal plants used by people of Raipur in Dehradun District, Uttarakhand. J Appl Ecol. 2014;2:16–22.
10. Patil SM, Dubal K, Dongare M, Kale M. Investigation of chemical composition from *Dryopteris cochleata* (D. Don) C. Chr. (Dryopteridaceae). Asian J Pharma Clin Res. 2015;8(4):1–4.

